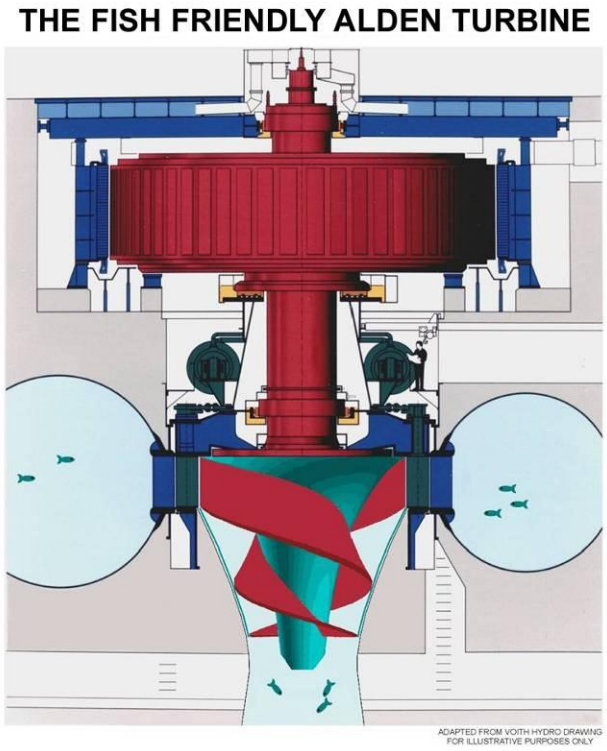
Jun 6th, 10:30 AM - 10:50 AM

Session D4 - EPRI's Program to Develop, Install and Test the Alden Fish-Friendly Hydropower Turbine

Douglas Dixon
Alden Research Laboratory, Inc.



EPRI | ELECTRIC POWER RESEARCH INSTITUTE

Re-inventing the Wheel:

The Continuing Story of the Alden Turbine Development

Douglas A. Dixon

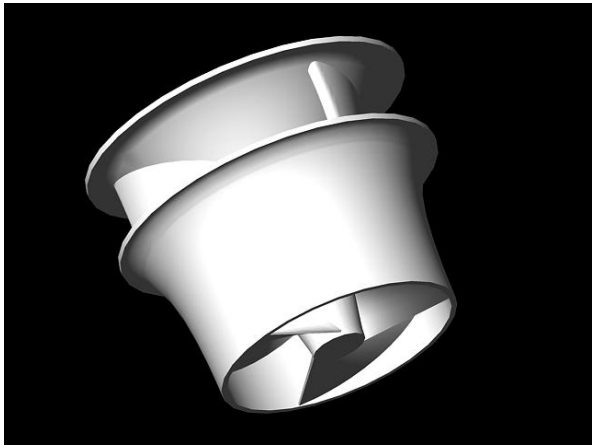
National Conference on Engineering and Ecohydrology for Fish Passage

June 5-7, 2012

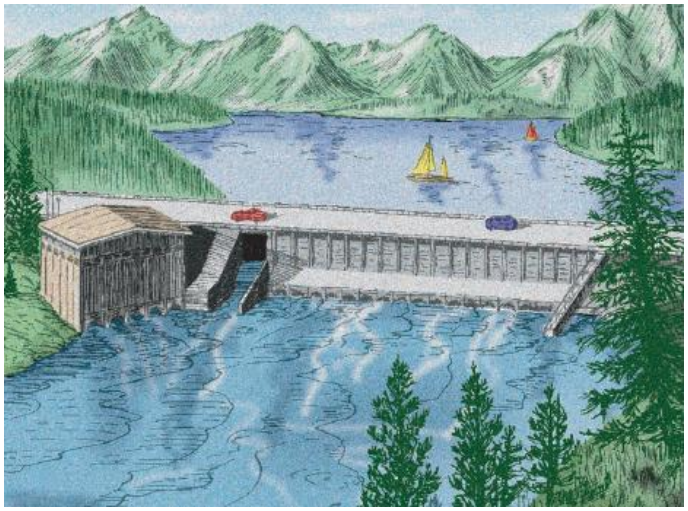
Presentation Topics

- Brief history
- Key turbine features
- Current status
- Hydro potential
- Planned but canceled demonstration projects – alternative plan
- Features of ideal demonstration site

Alden Turbine Status Summary



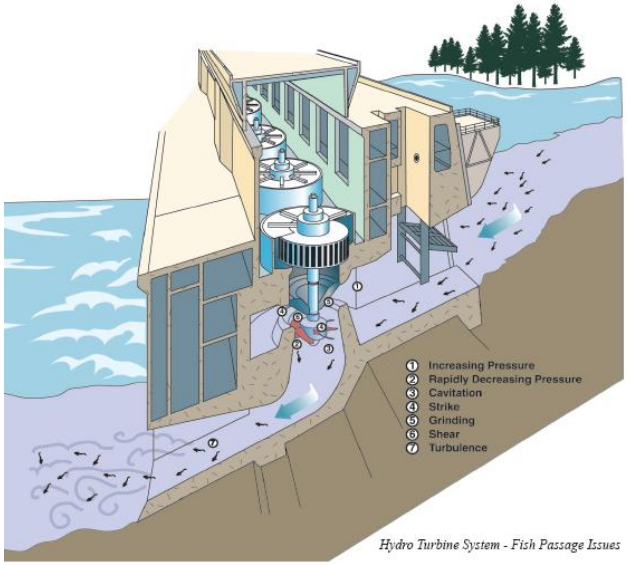
- **EPRI, DOE & Industry funding of $2.6 million:**
  - Buildable turbine design from collaborative completed
  - Model test indicates favorable turbine performance

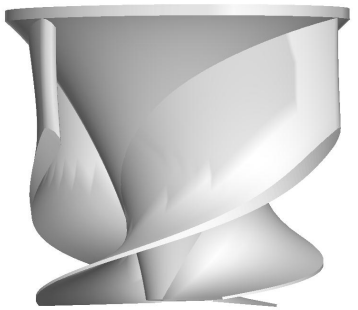


- Ready for purchase, deployment and field demonstration
- Seeking field site for 2013~15 Demonstration Program

Brief History of the Alden Turbine

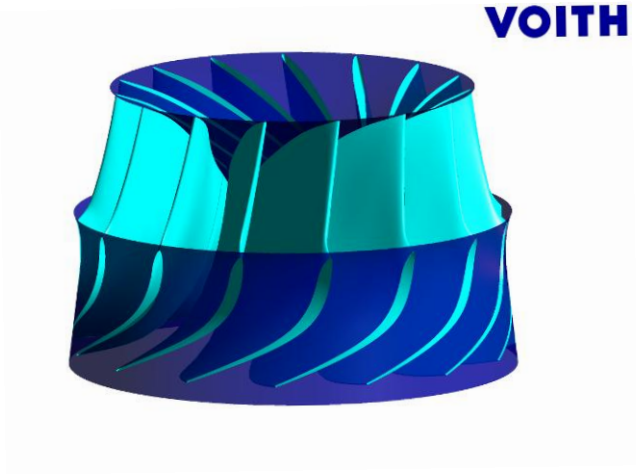
- 1995 EPRI-Industry-DOE Advanced turbine program
- Two turbine designs emerged: Minimum gap runner (MGR) and the **Alden Turbine**
  - MGR installed & tested (limited) in Pacific NW
  - Alden turbine only tested at pilot scale
- DOE Program canceled 2005
- EPRI took over Alden turbine's continued development



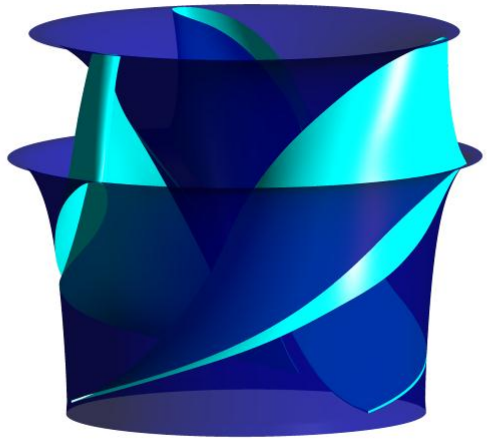


“Fish Friendly” Turbine Development: Alden Design - What’s Different?

VOITH

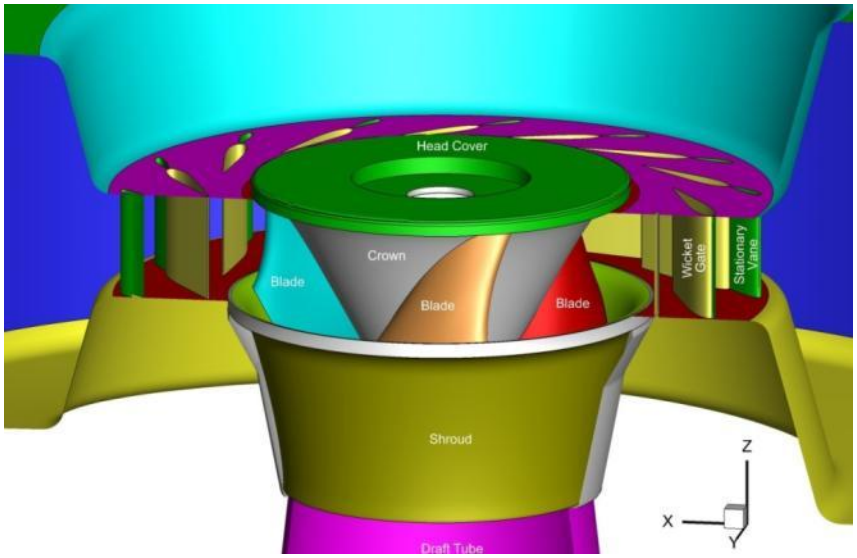


Conventional Francis Turbine

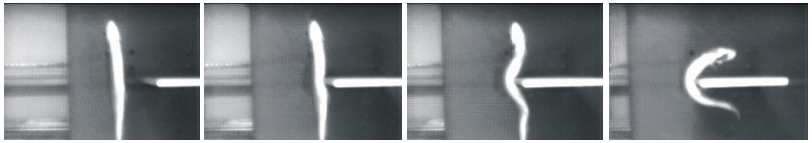


Alden Turbine

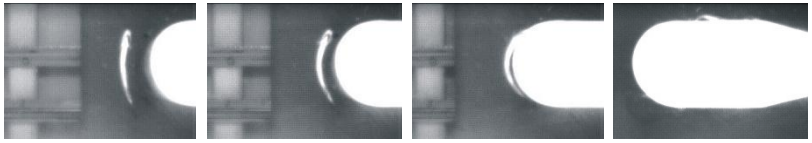
What Makes it Fish-Friendly?



Fish Length=250 mm; Blade thickness=10 mm; Velocity=7.3 m/s

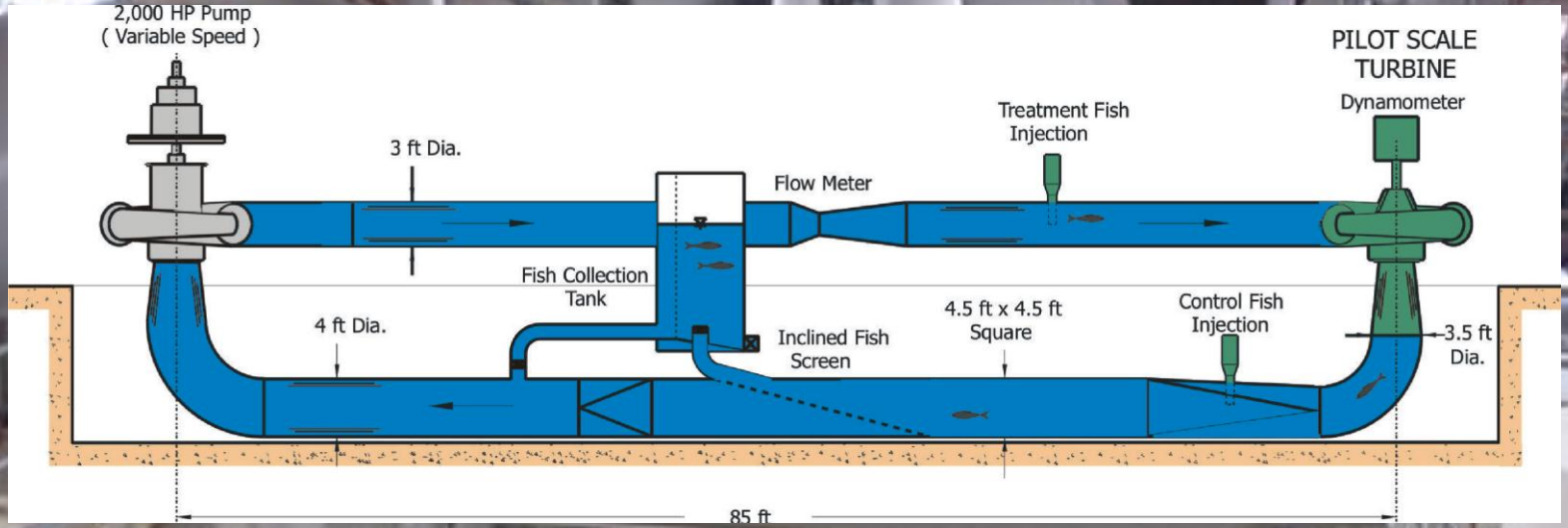


Fish Length=150 mm; Blade thickness=150 mm; Velocity=7.3 m/s



- Large diameter
- Slow rotational speed
- Few blades (3)
- No gaps
- Thick leading edges on blades
- Thick leading edges on vanes and gates
- Biological design criteria – eliminated damaging shear and pressure

Alden Turbine Pilot Scale Test Loop



>42,000 fish tested

Predicted Fish Survival

SPECIES TESTED


American eel


White sturgeon


Coho salmon


Rainbow trout


Smallmouth bass


Alewife

PREDICTED FULL-SCALE SURVIVAL

97 – 100 %

(based on pilot scale survival data)

Alden Turbine – Comparison with Conventional Turbines: Fish Survivability

	Alden Turbine	Conventional Francis	Conventional MGR Kaplan
Power, [MW]	13.6	13.6	13.6
Survival rate for an 8” fish (considering strike)	98%	< 50%	86%

EPRI-DOE Advanced Turbine Research: Conceptual to Engineering Design

U.S. DEPARTMENT OF ENERGY

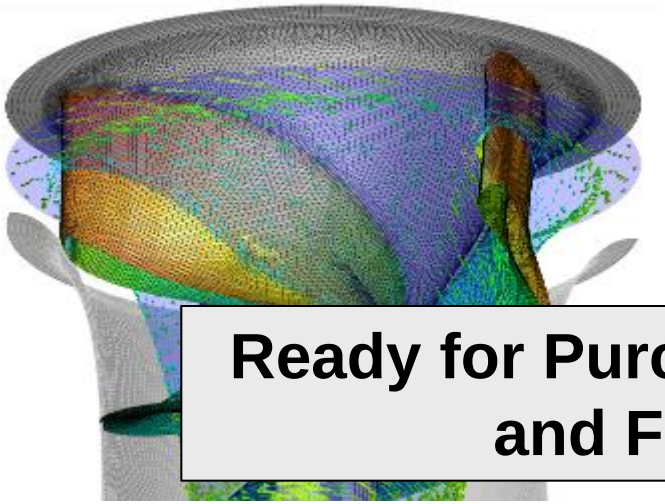
$1.2 million DOE

$1.4 million EPRI & industry

VOITH HYDRO POWER GENERATION

ALDEN Solving flow problems since 1894

+ 8 Industry Co-sponsors



- Spring 2010: Design Engineering
- Summer-Fall 2010: Constructed and tested a physical model: **94% efficient and wide operating range at peak performance**

Ready for Purchase, Deployment and Field Testing

...nal design, ...dule

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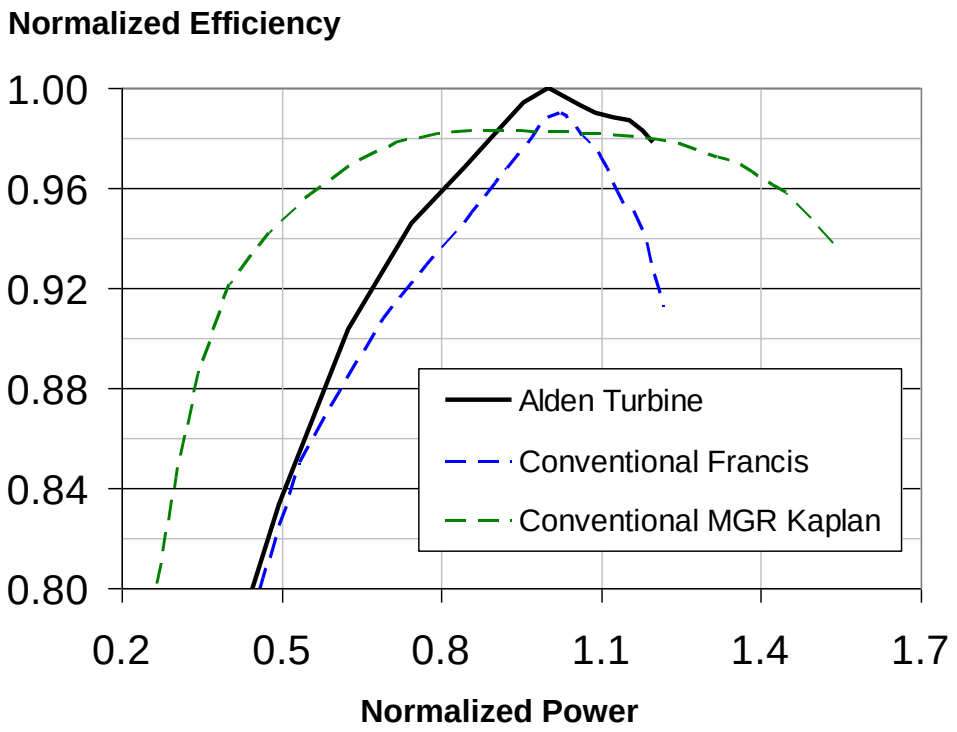
Turbine Prototype Performance



- Mechanical design review indicates it is readily implementable for a range of applications
- Performance exceeded expectations
- Thrust, runaway speed, and pressure pulsations were within anticipated ranges
- No cavitation for the operating conditions corresponding to design point

VOITH HYDRO
POWER GENERATION

Relative Prototype Costs

	Alden Turbine	Conventional Francis	Conventional Kaplan
SIZING			
Diameter (mm)			2650
Power (MW)			11
Turbine	1	0.5	0.55
Generator	0.8	0.65	0.65
Installation and Comm.	0.25	0.25	0.25
Automation/ BoP	0.25	0.25	0.25
Relative Costs	2.3	1.65	1.7
Premium for Alden		39%	35%

But…….

Relative Costs (continued)

Offsetting benefits

- Less powerhouse excavation (higher turbine setting)
- Generating with bypass flow (previously wasted/spilled)
- Avoid O&M and capital costs for downstream fish bypass systems

True costs comparison of project components may be less for a Alden unit than conventional Francis or Kaplan units

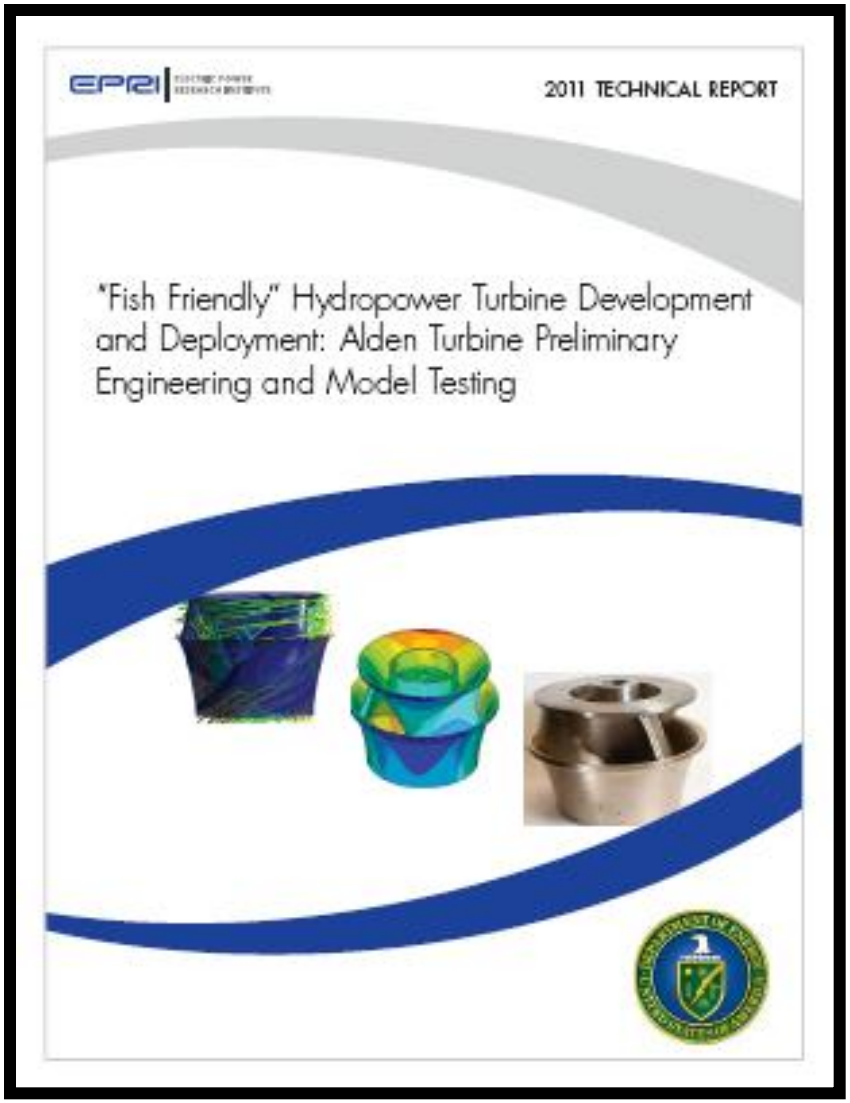
True Cost Comparison

ALDEN	<	Conv. Turbine	+	Fish Bypass	+	Lost Energy

EPRI-DOE Design & Model Performance Report

EPRI Report 1019890, September 2011

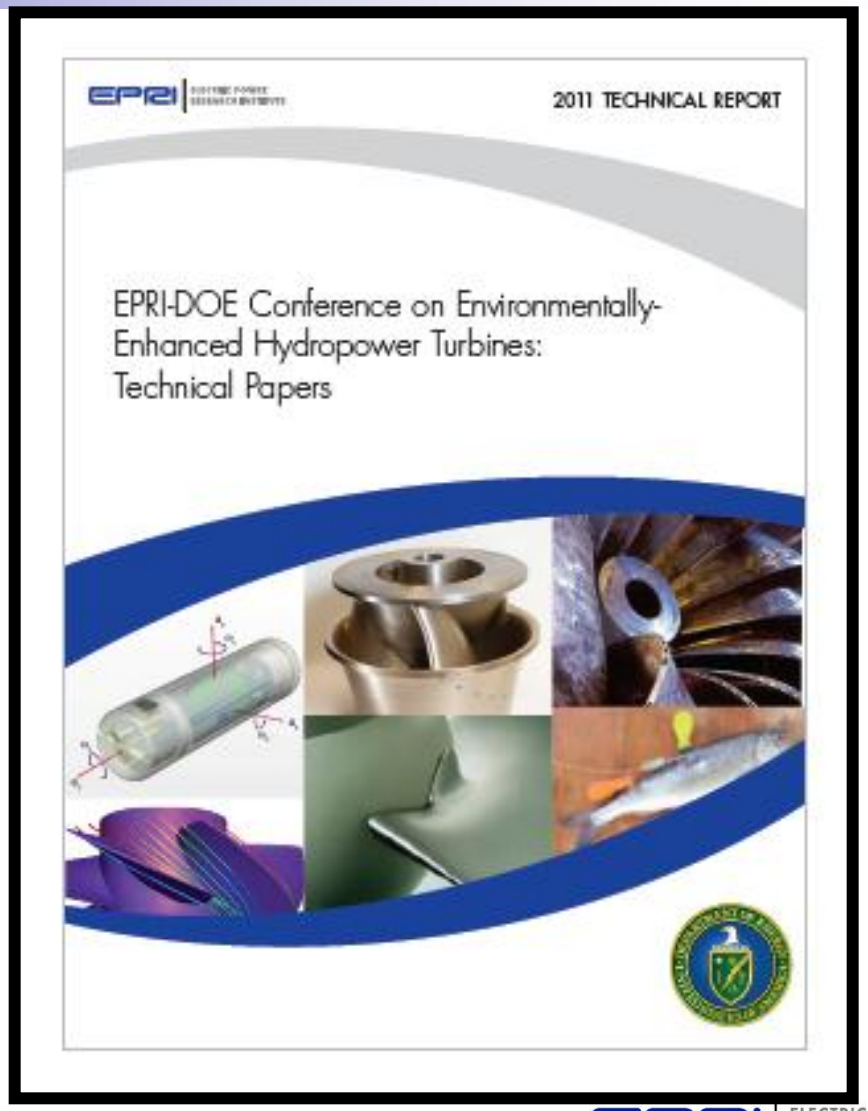
Download at www.epri.com



Info on All Enhanced Turbines

Technical Papers from EPRI-DOE-BOR-COE-NHA 2011 Conference

Report 1024609

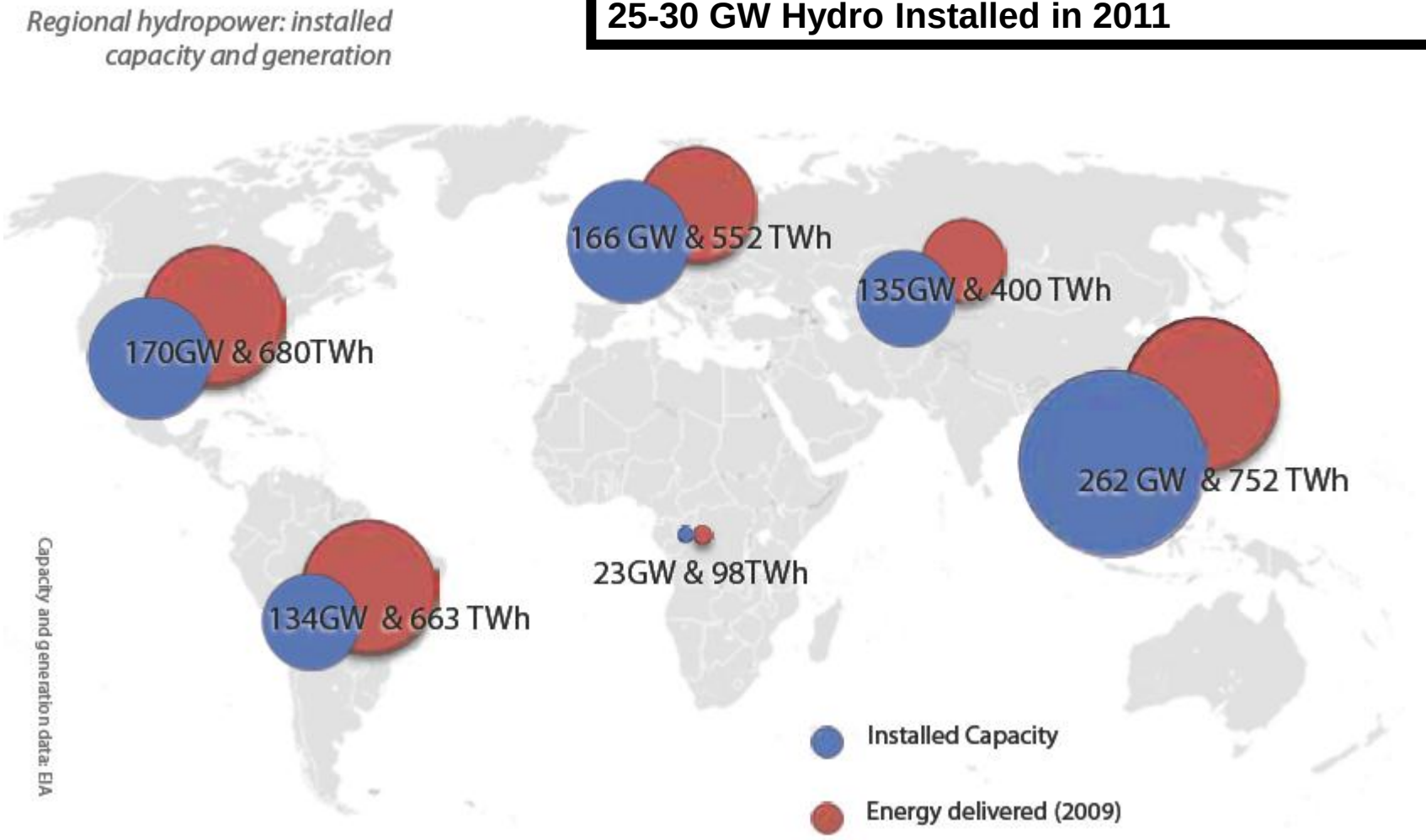


Where Can This Turbine Be Used?

- New development
- Added capacity at existing dams
- Powering non-powered dams
- Minimum flow releases and other bypass systems
- Not planned as modernization turbine; but
  - Unit replacement or upgrade (10-60 m^3/s; 10~40 m head)

Worldwide Installed Hydro Capacity (EIA)

25-30 GW Hydro Installed in 2011



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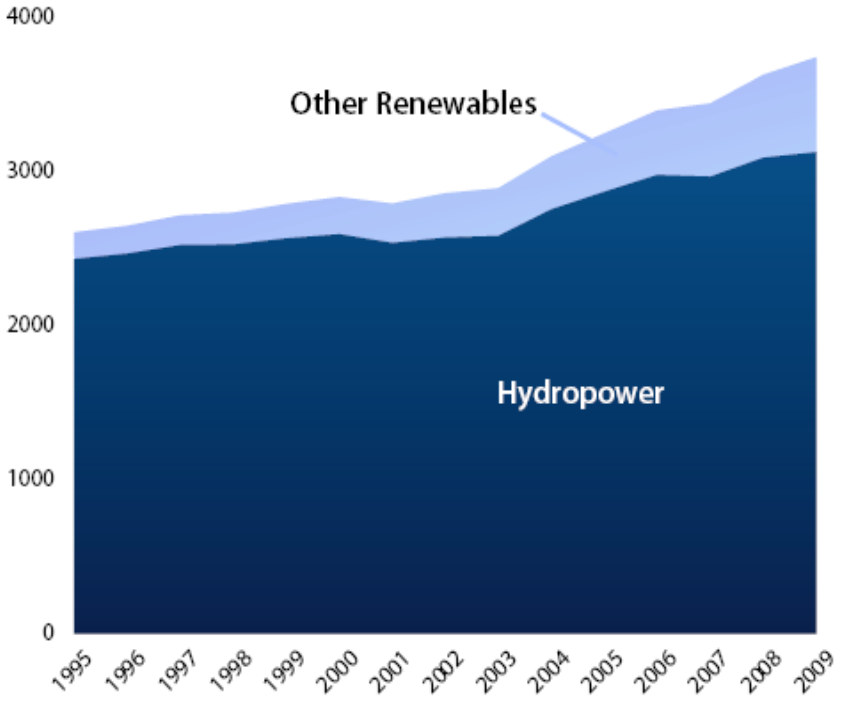
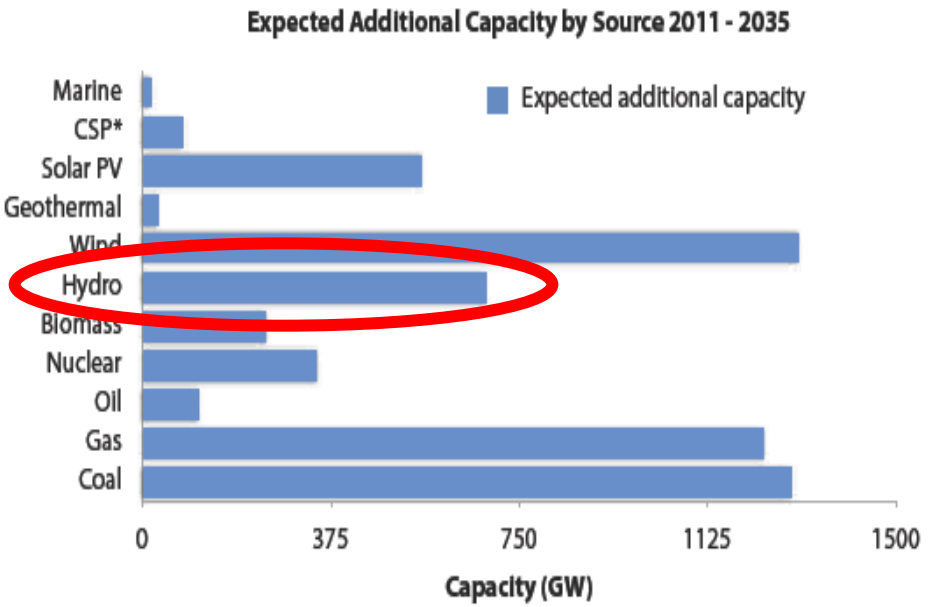
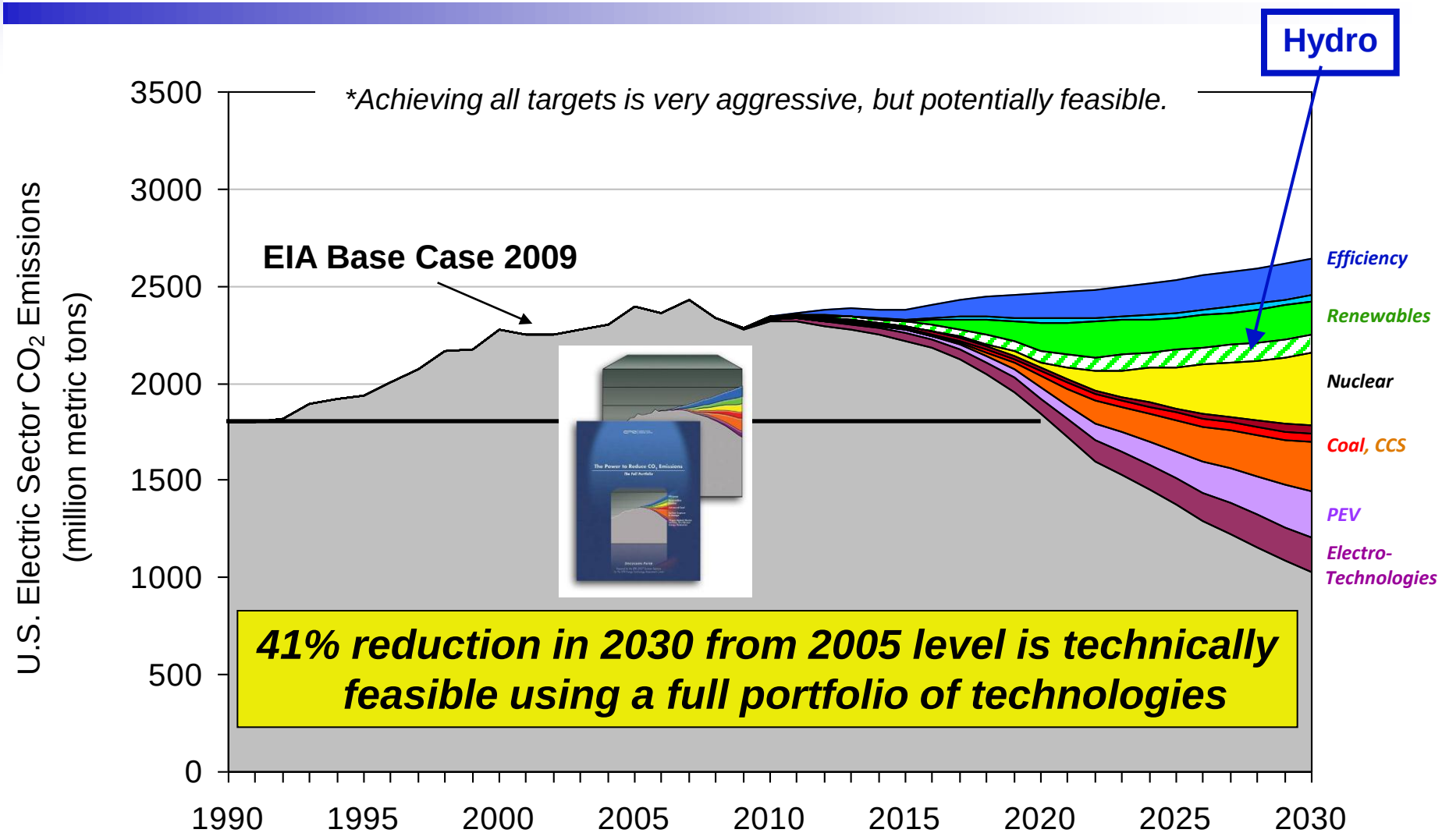
Hydro Worldwide Growth Predictions (EIA)



Progress of renewable electricity since 1995 (source: EIA)



U.S. CO_2 Reductions … Technical Potential (EPRI PRISM Analysis)



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Why Demonstration?

Many to convince that this new technology is viable:

- Resource agencies
- NGOs (environmental groups)
- Industry (need better handle on cost & performance economics)

NEED Demos to reduce uncertainties in performance and cost and we need collaborative support to continue!

U.S. Demo

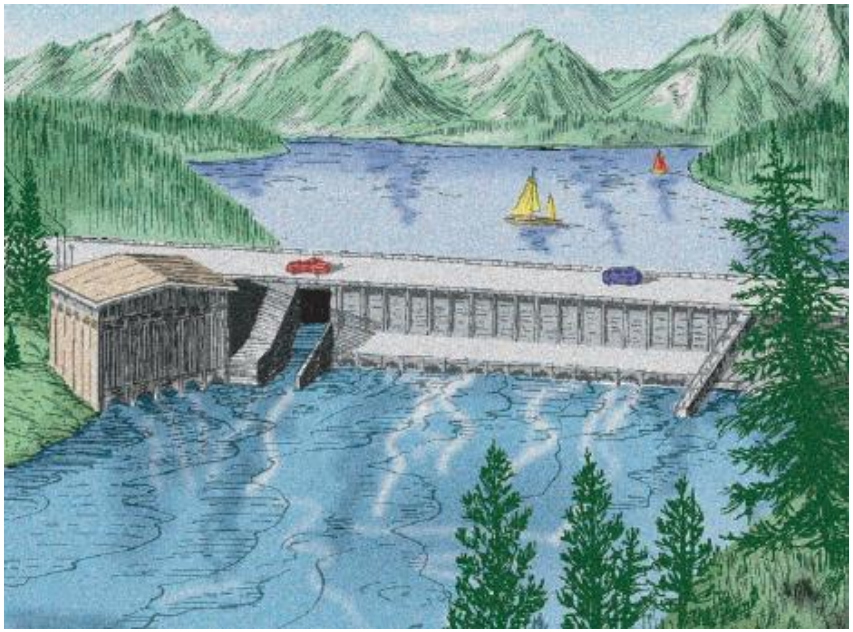
- **April 2011 U.S. DOE FOA for Advanced Hydro Technologies**
- **September 2011 U.S. DOE Announcement:**
  - **EPRI Awarded $1.5 million to Support Brookfield Demonstration Project**
  - **$1.5 million cash match requirement**
- **EPRI has requested DOE approval for finding a new demo site**

Potential new demo sites:

- Federal facility (Reclamation, Corps)
- FERC exempt site
- FERC site (private operator)

Preferred/Ideal Features of a Test Site

- **Head** = 75’ to 100’
- **Flow** = 1,000 cfs to 1,800 cfs
- **Fish Species** – juvenile anadromous salmon and/or herring, juvenile landlocked salmon, rainbow trout, juvenile sturgeon, adult catadromous eels

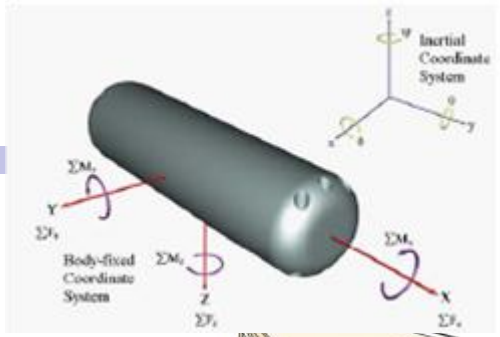


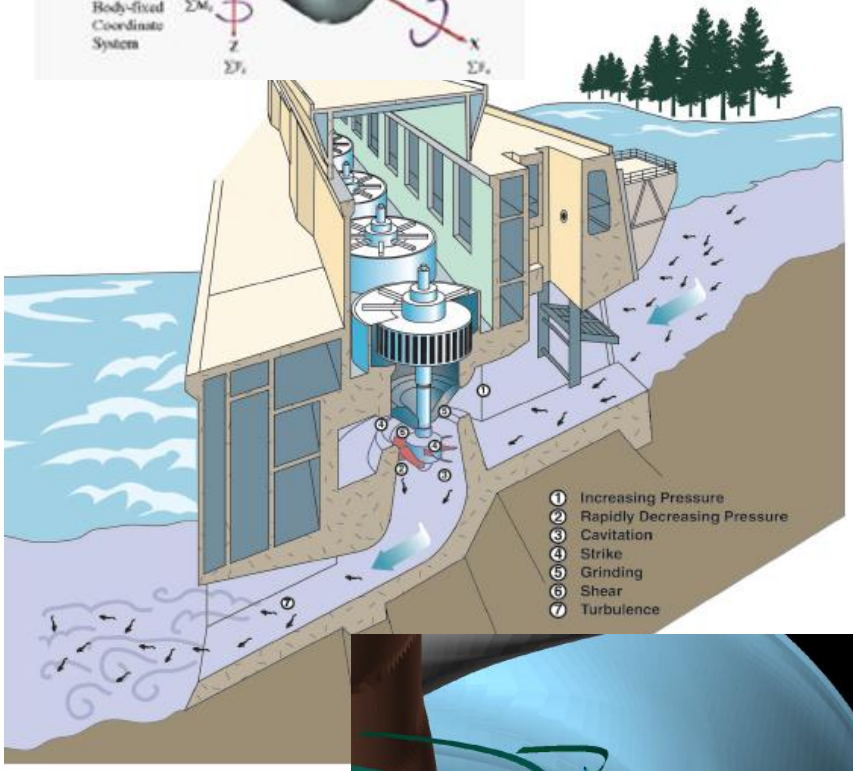
Revised Proposed Project Schedule

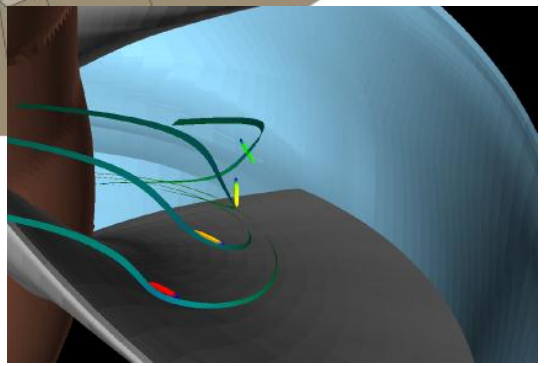
Schedule:

- 2013: adapt turbine engineering design to site, preliminary installation design, turbine manufacture and delivery
- ~2014: Installation
- ~2015-16: Performance testing

Future Testing







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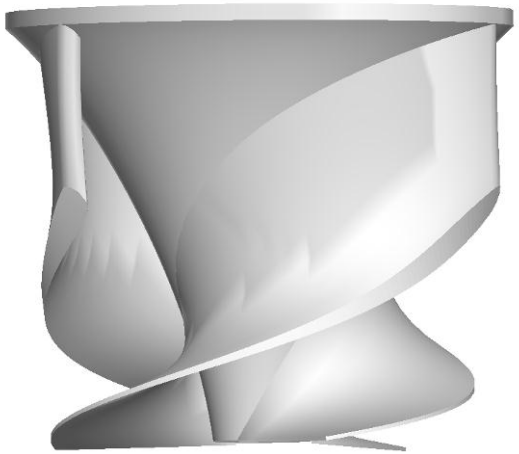
SUMMARY

EPRI preparing to move this turbine to its next step:

- Get it in the water, get it tested, get results
- EPRI recognizes risks and is prepared to help minimize them
- **Continued industry & public support needed to make it happen!**



Thank You DOE, Funding Partners and R&D Team!

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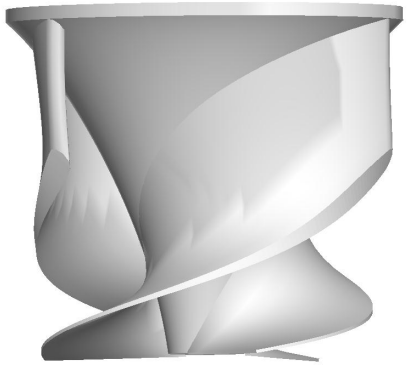
EPRI, DOE and the Hydropower Industry

Together…Shaping the Future of Electricity



THANK YOU! Doug Dixon, ddixon@epri.com;

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